IN THE SPECIFICATION

Please amend the specification, as follows:

The paragraph on page 1, lines 6-9, should read:

--This application claims the benefit of US Provisional Patent Applications, Serial No. 60/410,541 (CiDRA Docket No. CC-543), filed Sept. 12, 2002, and is a continuation-in-part of US Patent Applications, Serial No. 10/645,689 ~~(CiDRA Docket No. CC-0648)~~, each of which are incorporated herein by reference in their entirety. --

The paragraph on page 1, lines 10-13, should read:

--US Patent Application Serial No. 10/661,082 (publication no. US 2004 - 0179267 A1), filed concurrently herewith, entitled "Method and Apparatus for Labeling Using Diffraction Grating -Based Encoded Optical Identification Element" ~~(CiDRA Docket No. CC-0650A)~~, filed contemporaneously herewith, contains subject matter related to that disclosed herein, which is incorporated by reference in its entirety.--

The paragraph on page 2, lines 5-10 should read:

--According to the present invention, an encoded particle includes a particle substrate; at least a portion of the substrate having at least one diffraction grating disposed therein, the grating having a resultant refractive index variation at a grating location, the grating being embedded within a substantially single material of said substrate; and the grating providing an output optical signal indicative of a code when illuminated by an incident light signal propagating in free space, the output optical signal being a result of passive, non-resonant scattering from the grating when illuminated by the incident light signal ~~an optical identification element, comprises an optical substrate; at least a portion of the substrate having at least one diffraction grating disposed therein, the grating having at least one refractive index pitch superimposed at a common location; the grating providing~~

~~an output optical signal when illuminated by an incident light signal; and the optical output signal being indicative of a code in the substrate.--~~

The paragraph on page 2, lines 21-25, should read:

--Also, the elements may be very small "microbeads" (or microelements or microparticles or encoded particles) for small applications (about 1-1000 microns)~~, or larger "macroelements" for larger applications (e.g., 1-1000mm or much larger)~~. The elements may also be referred to as encoded particles or encoded threads. ~~Also, the element may be embedded within or part of a larger substrate or object.~~ --

The paragraph on page 6, lines 27-30, should read:

--The grating 12 may also <u>be</u> referred to herein as a composite or collocated grating. Also, the grating 12 may be referred to as a "hologram", as the grating 12 transforms, translates, or filters an input optical signal to a predetermined desired optical output pattern or signal.--

The paragraph on page 10, lines 3-8, should read:

--The reflected light 26-36 passes through a lens 37, which provides focused light beams 46-56 which are imaged onto a CCD camera 60 <u>as indicated by reference numerals 122, 124, 126, 128, 130 and 130</u>. Instead of or in addition to the lens 37, other imaging optics may be used to provide the desired characteristics of the optical image/signal onto the camera 60 (e.g., spots, lines, circles, ovals, etc.), depending on the shape of the substrate and input optical signals. Also, instead of a CCD camera other devices may be used to read/capture the output light.--

The paragraph on page 10, lines 9-11, should read:

--Referring to Fig. 7, the image 122, 124, 126, 128, 130 and 132 on the CCD camera 60 is a series of illuminated stripes 120 indicating ones and zeros of a digital pattern or code of the grating 12 in the element 8.--

The paragraph on page 10, lines 25-29, should read:

--Referring to Fig. 9, illustrations (a)-(c), for the grating 12 in a cylindrical substrate 10 having a sample spectral 17 bit code (i.e., 17 different pitches Λ1-Λ17), the corresponding image on the CCD (Charge Coupled Device) camera 60 is shown for a digital pattern of 17 bit locations 89, including Figure 9, illustrations (b), (c) and (d) , respectively, for 7 bits turned on (10110010001001001); 9 bits turned on of (11000101010100111); and all 17 bits turned on of (11111111111111111).--

The paragraph bridging pages 15-16 should read:

--Portions of the ~~to~~ above discussion of side grating reflection and the Bragg effect is also described in Krug P., et al, "Measurement of Index Modulation Along an Optical Fiber Bragg Grating", Optics Letters, Vol. 20 (No.17), pp.1767-1769, Sept. 1995, which are incorporated herein by reference.--

The paragraph bridging pages 19-20 should read:

--Referring to Fig. 15, the circular outer surface of the cylindrical substrate 10 causes a convex lensing effect which spreads out the reflected light beams as indicated by a line 294. The lens 37 collimates the reflected light 294 ~~290~~ which appears as a line 295. If the bottom of the substrate 10 was flat as indicated by a line 296 instead of curved (convex), the reflected light beam would not be spread out in this dimension, but would substantially retain the shape of the incident light (accounting for beam divergence), as indicated by dashed lines 297. In that case, the output light would be spots or circles instead of lines.--

The paragraph on page 21, lines 16-29, should read:

--In Fig. 19, the bits may be detected by continuously scanning the input wavelength. A known optical source 300 provides the input light signal 24 of a coherent scanned wavelength input light shown as a graph 304. The source 300 provides a sync signal on a line 306 to a known reader 308. The sync signal may be a timed pulse or a voltage ramped signal, which is indicative of the wavelength being provided as the input light 24 to the substrate 10 at any given time. The reader 308 may be a photodiode, CCD camera, or other optical detection device that detects when an optical signal is present and provides an output signal on a line 309 indicative of the code in the substrate 10 or of the wavelengths present in the output light, which is directly related to the code, as discussed herein. The grating 12 reflects the input light 24 and provides an output light signal 310 to the reader 308. The wavelength of the input signal is set such that the reflected output light 310 through an optical lens 321 will be substantially in the center 314 of the Bragg envelope 312 for the individual grating pitch (or bit) being read.--

The paragraph on page 24, lines 18-23, should read:

--In this case, rather than having the input light 24 be incident at the conventional Bragg input angle θi, as discussed hereinbefore and indicated by a dashed line 701, the grating 12 is illuminated with the input light 24 oriented on a line 705 orthogonal to the longitudinal grating vector 703 ~~705~~. The input beam 24 will split into two (or more) beams of equal amplitude, where the exit angle θ_o can be determined from Eq. 1 with the input angle θ_i=0 (normal to the longitudinal axis of the grating 12). --

The paragraph bridging pages 24-25 should read:

--In particular, from Eq. 1, for a given grating pitch Λ1, the +/-1st order beams (m=+1 and m=-1) ~~,~~ corresponds to output beams 700,702, respectively, and ~~. For~~ the +/-2nd order beams (m=+2 and m=-2) ~~,~~ corresponds to output beams 704,706, respectively. The 0th order (undiffracted) ~~(undefracted)~~ beam (m=0) ~~,~~ corresponds to beam 708 and passes straight through the substrate. The output

beams 700-708 project spectral spots or peaks 710-718, respectively, along a common plane, shown from the side by a line 709, which is parallel to the upper surface of the substrate 10. --

The paragraph on page 25, lines 13-21, should read:

--Referring to Fig. 24, if two pitches Λ1, Λ2 exist in the grating 12, two sets of peaks will exist. In particular, for a second grating pitch Λ2, the +/- 1st order beams (m = +1 and m = -1) ~~,~~ corresponds to output beams 720,722, respectively, and . For the +/- 2nd order beams (m = +2 and m = -2) ~~,~~ corresponds to output beams 724,726, respectively. The 0th order (~~un-defracted~~ un-diffracted) beam (m=0) ~~,~~ corresponds to beam 718 and passes straight through the substrate. The output beams 720-726 corresponding to the second pitch Λ2 project spectral spots or peaks 730-736, respectively, which are at a different location than the point 710-716, but along the same common plane, shown from the side by the line 709.--

The paragraph bridging pages 27-28 should read:

-- Referring to Fig. 27, instead of using an optical binary (0-1) code, an additional level of multiplexing may be provided by having the optical code use other numerical bases, if intensity levels of each bit are used to indicate code information. This could be achieved by having a corresponding magnitude (or strength) of the refractive index change (δn) for each grating pitch Λ. In Fig. 27, four intensity ranges are shown for each bit number or pitch Λ, providing for a Base-4 code (where each bit corresponds to 0,1,2, or 3). The lowest intensity level, corresponding to a 0, would exist when this pitch Λ is not present in the grating. The next intensity level 450 would occur when a first low level δn1 exists in the grating that provides an output signal within the intensity range

corresponding to a 1. The next intensity level 452 would occur when a second higher level $\delta n2$ exists in the grating 12 that provides an output signal within the intensity range corresponding to a 2. The next intensity level 454 ~~452~~, would occur when a third higher level $\delta n3$ exists in the grating 12 that provides an output signal within the intensity range corresponding to a 3. Accordingly, an additional level of multiplexing may be provided.-

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The paragraph on page 28, lines 9-11, should read:

--Referring to Figs. 36,38, alternatively, the substrate 10 may have more than one region 80, 82, 84, 86, 88, 90 ~~20~~ having codes code 1, code 2, code 3, ..., code N. For example, there may be two gratings side-by-side, or spaced end-to-end, such as that shown in Figs. 33,38, respectively.--

The paragraph bridging pages 29-30 should read:

--Referring to Fig. 41 illustrations (a), (b), (c), (d), and (e) the substrate 10 may have one or more holes located within the substrate 10. In illustration (a), holes 560 may be located at various points along all or a portion of the length of the substrate 10. The holes need not pass all the way through the substrate 10. Any number, size and spacing for the holes 560 may be used if desired. In illustration (b), holes 572 may be located very close together to form a honeycomb-like area of all or a portion of the cross-section. In illustration (c), one (or more) inner hole 566 may be located in the center of the substrate 10 or anywhere inside of where the grating region(s) 20 are located. The inner hole 566 (or any holes described herein) may be coated with a reflective coating 573 to reflect light to facilitate reading of one or more of the gratings 12 and/or to reflect light diffracted off one or more of the gratings 12. The incident light 24 may reflect off the grating 12 in the region 20 and then reflect off the surface 573 to provide output light 577. Alternatively, the incident light 24 may reflect off the surface 573, then reflect off the grating 12 and provide the output light 575. In

that case the grating region 20 may run axially or circumferentially 571 around the substrate 10. In illustration (d), the holes 579 may be located circumferentially around the grating region 20 or transversely across the substrate 10. In illustration (e), the grating 12 may be located circumferentially (and running up-down) around the outside of the substrate 10, and there may be holes 574 inside the substrate 10. Alternatively, the grating 12 may be located circumferentially (and running circumferentially) around the outside of the substrate 10. In that case, the incident light 24 reflects of the grating 12 to provide the output light 576 as shown.--

The paragraph bridging pages 30-31 should read:

--Referring to Fig. 43, illustrations (a), (b), (c) a D-shaped substrate, a flat-sided substrate and an eye-shaped (or clam-shell or teardrop shaped) substrate 10, respectively, are shown. Also, the grating region 20 may have end cross-sectional shapes other than circular and may have side cross-sectional shapes other than rectangular, such as any of the geometries described herein for the substrate 10. For example, the grating region 20 may have a oval cross-sectional shape ~~as shown by dashed lines 581~~, which may be oriented in a desired direction, consistent with the teachings herein. Any other geometries for the substrate 10 or the grating region 20 may be used if desired, as described herein. In the case of an oval shaped grating region 20 may provide high diffraction efficiency, when light is incident on the long side of the oval.--

The paragraph on page 31, lines 9-13, should read:

--Referring to Fig. 28, the elements 8 may be placed in a tray or plate 207 with grooves 205 to allow the elements 8 ~~10~~ to be aligned in a predetermined direction for illumination and reading/detection as discussed herein. Alternatively, the grooves 205 may have holes 210 that provide suction to keep the elements 8 in position. The groove plate 207 may be illuminated from the top, side or the bottom of the plate.--

The paragraph bridging pages 31-32 should read:

--Referring to Figs. 28 and 31, alternatively, the surfaces inside the V-grooves 205 may be made of or coated with a reflective material that reflects the incident light. A light beam is incident onto the substrate and diffracted by the grating 12. In particular, the diffracted beam may be reflected by a surface 520 of the V-groove 205 and read as an output beam 522 from the same direction as the incident beam 24. Alternatively, referring to Figs. 28 and 32, the incident light beam 24 may be diffracted by the grating 12 and pass through the upper surface 529 of the v-groove and reflected off two surfaces 526, 528 which are made or coated with a reflective coating to redirect the output beam upward as a output light beam 530 which may be detected as discussed hereinbefore.--

The paragraph bridging pages 33-34 should read:

--Referring to Fig. 47, if the value of n1 in the grating region 20 is greater than the value of n2 in the non-grating region 18, the grating region 20 of the substrate 10 will act as a known optical waveguide for certain wavelengths. In that case, the grating region 20 acts as a "core" along which light is guided and the outer region 18 acts as a "cladding" which helps confine or guide the light. Also, such a waveguide will have a known "numerical aperture" (θna) that will allow light 630 that is within the aperture θna to be directed or guided along the grating axis 207 and reflected axially off the grating 12 and returned and guided along the waveguide. In that case, the grating 12 will reflect light having the appropriate wavelengths equal to the pitches Λ present in the grating 12 back along the region 20 (or core) of the waveguide, and pass the remaining wavelengths of light as the light 632. Thus, having the grating region 20 act as an optical waveguide for wavelengths reflected by the grating 12 allows incident light that is not aligned exactly with the grating axis 207 to be guided along and aligned with the grating 12 axis 207 for optimal grating reflection.--

The paragraph on page 35, lines 8-17, should read:

--Referring to Fig. 52, if the light 240 is incident along the grating axis 207 (Figs. 11 & 45), alignment may be achieved by using a plate 674 having holes 676 slightly larger than the elements 8. The incident light 670 is reflected off the grating and exits through the end as a light 672 and the remaining light passes through the grating and the plate 674 as a line 678. Alternatively, if a blazed grating is used, as discussed hereinbefore with Fig. 51, incident light 670 may be reflected out the side of the plate (or any other desired angle), as indicated by a line 680. Alternatively, input light may be incident from the side of the plate 674 and reflected out the top of the plate <u>674</u> ~~474~~ as indicated by a line 684. The light 672 may be a plurality of separate light beams or a single light beam that illuminates the entire tray 674 if desired.--